



Article

Variable Decomposition for Large-Scale Constrained Optimization Problems Using a Grouping Genetic Algorithm

Guadalupe Carmona-Arroyo ^{*}, Marcela Quiroz-Castellanos ^{*✉} and Efrén Mezura-Montes [✉]

Artificial Intelligence Research Institute, Universidad Veracruzana, Campus Sur, Calle Paseo Lote B, Sección Segunda, 112, Nuevo Xalapa, Veracruz 91097, Mexico; emezura@uv.mx

^{*} Correspondence: gcarmonaarroyo@gmail.com (G.C.-A.); maquiroz@uv.mx (MQ.-C.)

Abstract: Several real optimization problems are very difficult, and their optimal solutions cannot be found with a traditional method. Moreover, for some of these problems, the large number of decision variables is a major contributing factor to their complexity; they are known as Large-Scale Optimization Problems, and various strategies have been proposed to deal with them. One of the most popular tools is called Cooperative Co-Evolution, which works through a decomposition of the decision variables into smaller subproblems or variables subgroups, which are optimized separately and cooperate to finally create a complete solution of the original problem. This kind of decomposition can be handled as a combinatorial optimization problem where we want to group variables that interact with each other. In this work, we propose a Grouping Genetic Algorithm to optimize the variable decomposition by reducing their interaction. Although the Cooperative Co-Evolution approach is widely used to deal with unconstrained optimization problems, there are few works related to constrained problems. Therefore, our experiments were performed on a test benchmark of 18 constrained functions under 100, 500, and 1000 variables. The results obtained indicate that a Grouping Genetic Algorithm is an appropriate tool to optimize the variable decomposition for Large-Scale Constrained Optimization Problems, outperforming the decomposition obtained by a state-of-the-art genetic algorithm.

Keywords: Grouping Genetic Algorithm; variable decomposition; Large-Scale Constrained Optimization



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1. Introduction

A constrained numerical optimization problem is defined by finding the vector $\mathbf{x} \in \mathbb{R}^D$ that minimizes the objective function $Obj(\mathbf{x})$ subject to inequality $g_j(\mathbf{x})$ and equality $h_k(\mathbf{x})$ constraints [1]. This is described by Equation (1).

$$\begin{aligned} & \text{minimize} && Obj(\mathbf{x}) \\ & \text{subject to} && \\ & && g_j(\mathbf{x}) \leq 0, \quad j = 1, \dots, q \\ & && h_k(\mathbf{x}) = 0, \quad k = 1, \dots, r. \end{aligned} \tag{1}$$

where q and r represent the number of inequality and equality constraints, respectively, $\mathbf{x} = (x_1, \dots, x_D)$, and the search space S is defined by the lower limits l and upper limits u ($l_i \leq x_i \leq u_i$), while the feasible region is defined as the subset of solutions that satisfy the constraints of the problem $F \subset S$.

To handle the constrained problem, the constraint violation sum cvr [2], is calculated by Equation (2).

$$cvr(\mathbf{x}) = \sum_j^q \max(0, g_j(\mathbf{x})) + \sum_k^r \max(0, |h_k(\mathbf{x})| - \epsilon) \tag{2}$$

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